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THE OHIO RIVER POLLUTION SURVEY, METHODS AND PROGRESS

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THE OHIO RIVER POLLUTION SURVEY

METHODS AND PROGRESS

By

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Presented at thirteenth Ohio Conference on Sewage Treatment,
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The Ohio River Pollution Survey — Methods and Progress*

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The Ohio River and its tributary basin occupies an area of some 204,000 square miles and includes within this area portions of 14 states. According to a recent estimate, the total population of the Ohio Basin in 1930 was 17,530,000 and in 1940 is expected to reach about 18,440,000. The urban population of the basin in 1930 was 7,850,000, an increase of more than 5,000,000 since 1890 and more than 2,000,000 since 1915. The territory included within this basin is one of the most important agricultural and industrial sections of the United States.

In the years 1914-16 a comprehensive study was made of the pollution and natural purification of the Ohio River and in 1930-31 a more limited resurvey of the section from Cincinnati to Louisville, both of these investigations being conducted by the U. S. Public Health Service. Primary attention was given in both of these earlier studies to the sanitary condition of the Ohio River proper and of the main tributaries at their mouths. No information, except as to sources of pollution, was collected bearing on sanitary conditions in the streams of the vast area tributary to the Ohio, as the objectives of these studies were of a research character and thus were concerned with the more basic factors and relationships involved in the pollution and self-purification of the main river.

Within the past year, however, a new survey has been undertaken, embracing the entire Ohio Basin and with a definitely practical set of objectives, in contrast to the research character of the previous surveys. Officially designated as in the title of this paper, the new survey has been undertaken in accordance with a provision of Section 5 of the Rivers and Harbors Act of August, 1937, which author-

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ized and directed the Secretary of War to "cause a survey to be made of the Ohio River and its tributaries to ascertain what pollutive substances are being deposited, directly or indirectly, therein and the source and extent of such deposits, and with a view to determining the most feasible method of eliminating and correcting the pollution of these streams." This Act also provided for obtaining the active cooperation of the Public Health Service, for making a report to Congress with recommendations for remedial legislation, and for paying the expenses of the survey from current appropriations for rivers and harbors work.

In accordance with the foregoing provisions of the Act, the active assistance of the Public Health Service was requested by the War Department and after preliminary conference it was agreed that this agency would undertake the major part of the survey proper, including the collection of data relative to sources of pollution and also laboratory data concerning the sanitary quality of stream waters throughout the Ohio Basin. It was agreed that the U. S. Engineer Corps would collect and furnish all of the hydrometric data necessary to the survey, including both volumes and times of flow in the Ohio and its main tributaries. The Engineer Corps also undertook to assist the Public Health Service in the maintenance of certain mechanical equipment, by making available its excellent shop facilities at the Government dams.

In order to provide co-ordinated inter-departmental direction of the survey, an Ohio River Board was appointed by direction of the President, consisting of Brig. Gen. M. C. Tyler* of the Corps of Engineers, Senior Sanitary Engineer R. E. Tarbett of the Public Health Service and Mr. Abel Wolman, representing the National Resources Committee and public health agencies outside the Government service. As the result of preliminary conferences it was decided that the laboratory studies

*Gen. Tyler has been recently succeeded by Brig. Gen. T. M. Robins as member of this Board.

would be conducted by the Stream Pollution Investigations Station of the Public Health Service at Cincinnati and the field surveys of sources of pollution, by the Office of Stream Sanitation of this Service, also headquartered at Cincinnati. The present authors were assigned immediately in charge of these two divisions of the work. A special activity connected with the survey, but not directly concerned with these two divisions, has been an epidemiological study of water-borne diseases under the immediate charge of Surgeon Filip Forsbeck of the Public Health Service. In Figure 1 is shown a complete organization chart for the present staff, indicating the administrative relationships of the various units. The active full-time staff now consists of 51 workers, of whom 31 are assigned to the laboratory surveys, 17 to the field surveys and 3 to the epidemiological study.

(Insert Figure 1)

As it appeared from preliminary estimates that approximately three years would be required in which to complete the survey, it was decided to devote the first year to that section of the main river, comprising roughly its middle third, extending from the mouth of the Kanawha River downstream to the mouth of the Kentucky River, a distance of about 280 miles. The territory thus included embraces both the main stem of the Ohio and some 30,000 square miles of tributary drainage area, including both the Kanawha and Kentucky watersheds. In Figure 2 is shown a map of the Ohio River Basin outlining the area being covered during the first year and in addition, the Tennessee and Cumberland watersheds, where data are being collected through the Tennessee Valley Authority and the Tennessee Department of Health. This map also shows the locations of the main sampling stations for the laboratory examination of stream waters in the 1939 survey area.

(Insert Figure 2)

FIELD SURVEYS OF SOURCES OF POLLUTION

Four State Health Departments Become Headquarters for Field Engineers

The right hand section of the chart shown in Figure 1 indicates the type of organization which the Office of Stream Sanitation, with headquarters at 1309 Cincinnati Enquirer Building, Cincinnati, has developed to assemble quickly and economically (1) the information on public water supplies using the streams as sources of drinking water, (2) data on sewage disposal in cities discharging wastes into the Ohio and its tributaries, (3) data on the industrial wastes which flow into the streams with their burden of acid or organic matter having high oxygen consuming properties, and (4) the effect of such wastes on the normal uses of the stream including, in addition to public and industrial water supply, aquatic and wild life, recreational developments and agricultural uses.

The Office of Stream Sanitation first worked out a detailed plan to cooperate with all State health departments and State agencies concerned with water uses in the Ohio River Basin. Following out the same cooperative type of effort which the Service has carried out with State health departments over a period of twenty or more years on railroad water supply certification, milk sanitation and general public health administration, an agreement was reached whereby two public health engineers were quartered with the State Health Departments in Ohio, Kentucky, West Virginia and Tennessee, working in close cooperation with the Sanitary Engineering Division of each state. The arrangement is proving mutually satisfactory. The Public Health Service is able to draw upon the extensive reservoirs of information in the State Health Departments' files, relating to raw water quality of public water supplies, drouth experiences when sewage pollution increases, sewerage systems, total population served by the systems, degree of treatment of the sewage, and efficiencies of sewage treatment devices. Perhaps of the greatest importance

is the opportunity to secure industrial wastes information by entering industrial plants as a friendly co-worker, through the latent good will of the State Health Department. Economy of time, money and effort has been a by-product of this close cooperative arrangement between the State and Federal sanitary engineers.

Ten River Basins in 1939 Study Area

Before outlining the degree to which the work has progressed in the eight months of this first year's work of the survey, it may be worth while to list the drainage basins under study and explain how an additional cooperative arrangement is working with the Tennessee Valley Authority, another Federal agency, which has been carrying forward extensive studies in the stream pollution field over a three year period.

In Ohio three drainage basins, the Little Miami, the Great Miami and the Scioto are being carefully studied this year.

In Kentucky the Licking, the Kentucky, and the Big Sandy Rivers have been focused upon, with reference to sources of pollution.

In West Virginia the three drainage basins are the Great Kanawha, which extends into the neighboring states of Virginia and North Carolina, the Guyandot and the Big Sandy, adjacent to the Kentucky area.

The above mentioned river systems will be completed in 1939 as far as obtaining complete data on the sources of pollution. However, the extensive Cumberland and Tennessee River systems which discharge their waters into the Ohio River not far from its mouth are also under investigation this year, but are not scheduled for completion. One field engineer is stationed at Chattanooga, Tennessee, the headquarters of the Tennessee Valley Authority working in the Tennessee River Basin; another, located at the State Health Department headquarters in Nashville, is work-

ing on sources of pollution in the Cumberland River Basin. The field work is being carried out somewhat differently in these two drainage basins, due to the stream sanitation program which has been under way for three years in the Tennessee and Cumberland Basins.

Reporting Systems for Transmittal of Data to Cincinnati Central Office

Reference to the appended samples of water supply, sewerage, sewage disposal and industrial wastes forms, together with the model form of the finished report as it is returned to the State health department, will indicate to those interested in stream sanitation surveys the channels which have been set up for the transmittal of data on sources of pollution on these ten river basins to the central office in Cincinnati in an orderly manner so that it will be useful, not alone to the State from which it came, and also it will be arranged in convenient form for determining the total pollution load on a particular stream and for ascertaining the results of such pollution and outlining necessary remedial measures.

Extent of Progress on River Basins

The maps shown in Figures 3 and 4 indicate the progreee to date with reference to the collection of field data for these ten drainage basins. The first map (Fig. 3) indicates the status of work with reference to public water supplies and sewage disposal; the second (Fig. 4) deals with the progress of industrial wastes disposal studies to date.

OHIO - In Ohio, the Little Miami Basin has been completed with reference to public water supplies, sewage disposal and industrial wastes. On the Great Miami River the water and sewerage program is 92% completed and the industrial wastes studies 66% finished. Work is now being started on the Scioto River Basin.

KENTUCKY - In Kentucky, the water supply, sewage disposal and industrial waste investigations on the Licking and Kentucky River Basins have been carried to completion. The field engineers are at work on the Big Sandy Basin, a portion of which lies in the adjacent states of West Virginia and Virginia.

WEST VIRGINIA - In West Virginia, the Great Kanawha Basin is 90% completed with reference to water supply and sewerage investigations. Because of the late start of the chemical engineer the industrial waste studies are only 14% completed. On the Big Sandy, the water and sewerage work is 40% completed in West Virginia and 9% finished in Kentucky. Industrial waste studies are 50% completed. Work has been started on the Guyandot River Basin.

Summary of Field Investigations to August 31, 1939

The eight field engineers in the States of Ohio, Kentucky, West Virginia and Tennessee, four of them assigned to water and sewerage work, and four of them working in connection with industrial waste studies, are carrying forward their programs with the hearty cooperation of the States, municipalities and industries alike. In the period of less than eight months since the beginning of the field work, 579 public water supplies and 579 sewerage systems and disposal plants, together with 223 industrial waste systems have been reported upon. The analysis of these data in the central office is now under way, anticipating a preliminary report on the middle third of the basin early in 1940.

Sewage Disposal Improvement Trend

In the short time during which the study of sources of pollution has been underway, one outstanding feature has been noted with respect to sewage disposal practices. In all of the states, the impetus given to improved methods for providing safe and sanitary sewage disposal by federal financial assistance has been great. Ohio gives an example of how rapid this change has come about. 114 new

sewage treatment plants were completed in this State in the five year period 1934-1938 inclusive, thus relieving the load on the streams tremendously. On the three watersheds under study fifty new sewage treatment plants are either in operation or under construction, as indicated in the following tabulation:

Three basins in Ohio - 1939 study	Number of Cities - Plants built 1937 - 1939	Approx. Cost of New Treatment Plants
Little Miami Basin	Six cities	$ 163,000
Great Miami Basin	Twenty-one cities	2,833,000
Scioto Basin	Twenty-three cities	5,586,000

These fifty cities, having a population of approximately three quarters of a million people, now have provided satisfactory disposal of their domestic and industrial wastes, a real achievement.

The above illustration has been shown to indicate the stimulus in the direction of improved sewage treatment in Ohio, and this trend is evident throughout the whole Ohio Basin. As contrasted with the conditions noted twenty-five years ago, when the former Ohio River studies were made, it is distinctly encouraging to find that rapid progress is being made in the abatement of stream pollution.

Industrial Wastes Disposal - Guides

Investigations to date of 223 industrial plants in the 1939 study area indicate that the disposal of industrial wastes without excessive burden on the oxygen resources of the receiving stream, is likely to be an outstanding problem. Therefore, the central office staff has endeavored to assemble industrial waste guides covering the industries operating in the Ohio River Basin. The purpose of these guides is to assist the field engineers working on industrial waste problems.

The seven guides which have been prepared to date are preliminary only and deal with the following industrial wastes:

1. Brewery Wastes
2. Tannery Wastes
3. Pulp Mill Wastes
4. Paper Mill Wastes
5. Corn Cannery Wastes
6. Slaughterhouse and Packinghouse Wastes
7. Milk Plant Wastes
8. Industrial wastes guides dealing with distillery wastes and tomato cannery wastes are now in preparation.

These guides, after being subjected to critical analysis by chemists and engineers in practice in their respective fields over the country, will be revised to the end that current, up-to-date information may be available showing quantity, quality, population equivalent and the best known methods of treatment for each type of waste. If possible, at a later date, these guides will be combined into one industrial waste publication. From all parts of the drainage basin, and over the country as a whole, helpful, constructive assistance is being given in preparing these guides.

Acid Mine Drainage - A Major Source of Pollution

Although one of the greatest sources of stream pollution in the Ohio Basin is acid mine drainage, the estimated total load from over 25,000 mines, in terms of acid calculated as C.P. sulphuric acid, being 2,451,000 tons per year, it will not be necessary for the field engineers to investigate and report upon this type of pollution. In cooperation with W.P.A. and several State health departments several years ago a regional W.P.A. project was set up for sealing abandoned mines and for ascertaining the total amount of acid mine drainage from both active and abandoned bituminous coal mines in the Ohio Basin. Relief workers in coal mining sections have been air-sealing abandoned mines in Ohio, Kentucky, West Virginia and Indiana for over four years. This has resulted in a measurable decrease in the acid load

being discharged into the streams, some of which lie in the drainage basins under study in 1939. The Mine Sealing organization - with headquarters in Pittsburgh, is gathering data showing the total acid load on each watershed, together with information showing the accomplishments brought about by the mine sealing work. This information is being sent in monthly to the Office of Stream Sanitation at Cincinnati, so that up-to-date information is available on the acid mine drainage pollution question.

Hydrometric Studies by Corps of Engineers - U. S. Army

In addition to knowing the sources of pollution and the amount and types of pollution, it is necessary to ascertain the stream flows in these ten drainage basins and in the main Ohio River. As the organization chart indicates,(Fig. 1) this important part of the Ohio River Pollution Survey is in charge of the Office of Division Engineer for the Ohio River Division, Corps of Engineers, U. S. Army.

The Corps of Engineers possesses excellent facilities for measuring stream flows in the Ohio and tributary streams, having access to records of stream flow extending over a long period of years, as well as cooperative relationships with the U. S. Geological Survey. The Cincinnati Office has detailed one or more engineers for the special purpose of gathering, tabulating and calculating stream flows, particularly the low flows. These data, which are being regularly received by the Office of Stream Sanitation, are necessary for proper interpretation of the results of the laboratory surveys which are outlined in the next section of this paper.

Laboratory Surveys

Active preparations for the laboratory surveys were begun in October, 1938, immediately after final arrangements had been completed for cooperation by the Public Health Service. The first step taken was the preparation of a definite plan of action, including a tentative listing of personnel and equipment and a decision as to the scope of the routine laboratory observations. The general plan of action decided upon was to establish two base laboratories on the Ohio River, each serving half of the total section under observation, as well as the lower portions of the tributary streams draining into the main river, and also to develop two mobile laboratories to serve the outlying portions of the tributary areas not readily accessible to the base laboratories.

Following this plan, a base laboratory was established first at Cincinnati, to serve the lower half of the Kanawha-Kentucky section or, more specifically, the stretch extending from Maysville to Carrollton, approximately 140 miles long. Active work was started in this section during January, 1939, after assembling the necessary equipment and personnel. In the meantime, through the courtesy of the Corps of Engineers, a large two-deck quarterboat, the Kiski, was loaned for use as a floating laboratory to serve the section of the Ohio above Maysville. Owing to unavoidable delays in obtaining the necessary furniture and other equipment, this laboratory boat could not be placed in active service until May, 1939, when it was moved, with its operating staff, to a point just above Ashland, Kentucky, at Dam 29. Meanwhile the laboratory personnel had been assembled and thoroughly trained at the Cincinnati base laboratory. Beginning June 1 and since then the Kiski laboratory has been located near Ashland, Kentucky and is covering the section of the Ohio from Maysville to Pt. Pleasant.

As auxiliary equipment for the two base laboratories, two 35-foot motor launches were obtained by loan from the U. S. Bureau of Fisheries early in the spring. These launches required thorough overhauling, having been out of service for more than two years, and also the construction of deck housing and other facilities for collection of samples and certain analytical work, such as dissolved oxygen determinations, in the field under all weather conditions. They are very rugged, seaworthy boats and have been extremely useful for intensive sampling work on the river.

Plans and specifications for two mobile trailer laboratory units were completed early in the spring of 1939 and these units were delivered late in the summer. Each unit consists of a stock model auto trailer, with special bench and laboratory equipment, and a towing car, which can be detached readily and used for the collection and transportation of samples.

Sample Collections

In order to cover the territory served by each base laboratory, automobiles are used to reach the more distant points along the main river and tributaries and the motorboats, for intensive sampling in the sections of the main river more immediately accessible to the laboratory. Through the courtesy of the Corps of Engineers, arrangements were made initially to have samples of Ohio River water collected at three-point sections in the Ohio River proper, located just above each Government dam. These collections have been maintained regularly, twice or three times weekly, at the 14 dams located from Gallipolis to Dam 39, thus affording a series of sampling points at average intervals of about 20 miles. The samples are collected early in the day and are called for and transported to the laboratory by automobiles, following a regular pre-arranged schedule.

Tributary collection points accessible from the base laboratories are reached by automobiles, the drivers acting also as collectors. In the Cincinnati area, samples above and below some 30 or more recognized sources of pollution, located on streams within a radius of about 50 miles, are being collected regularly in this way and a similar plan is being followed in the territory served by the laboratory boat Kiski.

The plan being followed by the mobile trailer laboratories is to locate at some central point in a given area for a period of one or two weeks and by means of the towing car, collect samples along the different streams in that area at points within a radius of 30 to 40 miles. After this work has been completed, the mobile laboratory unit is moved to the center of another area, usually contiguous to that which has just been covered.

Throughout the spring and summer, the biologist attached to the survey has been making frequent trips along the streams in each drainage area, collecting samples for examination and inspecting conditions which might influence the occurrence of various forms of organisms in the streams. Samples of water also have been collected regularly for biological examination at the routine sampling points, both in the Ohio and in the main tributaries. The examination of a portion of these samples will occupy the winter months, when field trips will necessarily be more restricted.

Under an arrangement for cooperation with the City of Cincinnati, a chemist employed by the City has been afforded the working facilities of the Cincinnati base laboratory for intensive work in the Cincinnati pool of the Ohio River. The chemist utilizes the survey's motor launch for collecting samples of river water in the vicinity of sewer outlets and near the water intake, where an effort is being made to determine whether the character of raw water entering the intake is

influenced occasionally by pollution from the Little Miami River or other local sources.

Analytical Data

The scope of the analytical data being obtained in this survey has been limited, so far as possible, to a minimum consistent with showing the general quality and degree of pollution of the stream waters in the area under observation. As a routine practice, the following determinations are made on the samples collected: temperature, turbidity, pH, alkalinity, total and volatile suspended matter, 24-hour bacterial plate count at 37° C., coliform bacterial enumerations (most probable numbers by fermentation test and direct count by brilliant green lactose plates), dissolved oxygen, and 5-day biochemical oxygen demand at 20° C. Nitrites are determined in a considerable portion of the samples, in order to check the necessity of using the azide modification in dissolved oxygen tests by the Winkler method. Total soap hardness is also being determined on typical stream samples throughout the area, as affecting the possible industrial uses of the streams. Occasionally nitrates are determined to check the presence or absence of nitrification in some streams.

Up to August 31, 1939, a total of 11,427 samples of stream waters had been collected in the survey operations and a total of 19,900 laboratory tests made on these samples, including 6,965 bacteriological tests. At the time of putting the mobile laboratories in the field, the number of samples collected was running about 2800 per month. With these laboratories now in operation, this number will be increased to some 4000 or 4500 per month.

Parallel coliform bacterial enumerations by direct plating and by the usual fermentation test method were undertaken on all routine samples with a view to ascertaining whether it would be feasible to use the direct plating method as a

substitute for the more cumbersome fermentation test under some conditions. The comparative results thus far have indicated that fairly accurate coliform enumerations can be obtained by the direct plating method in skilled hands where the numbers of these organisms present in a water are sufficiently high to give countable plates. It appears from our experience that at least two months of intensive work with the method may be required before the bacteriologist can attain the skill necessary to the accurate identification of typical colonies. For routine examination of surface streams and lakes, the method offers considerable promise for purposes of approximate classification with respect to relative pollution by sewage bacteria.

In general, the laboratory methods followed in the present survey have been the standard procedures recommended by the American Public Health Association. In order to obtain comparable results by the different laboratory units, a series of memoranda dealing with chemical, bacteriological and biological methods in somewhat more detail than in the Standard Methods was prepared initially by Messrs. Ruchhoft, Butterfield, Purdy and Lackey of the regular staff at the Cincinnati Stream Pollution Laboratory, for use by the new laboratory personnel assigned to the survey. Other prepared memoranda have dealt with the plan and objectives of the survey, with methods of sampling and other special matters.

Laboratory Results

In a brief paper of this kind, it is hardly practicable to undertake any detailed presentation or discussion of the results thus far obtained from the nearly 20,000 tests made up to the present writing. The best that appears feasible is to show by one or two illustrations the general trend of the more significant indicaters of pollution and to describe very briefly the conditions of pollution found along the Ohio and in some of its main tributaries and branches draining into the stretch of the main river now under observation.

In the main stem of the Ohio, two zones of relatively high pollution have been noted, one extending from Huntington to Portsmouth and the other, from Cincinnati 60 miles downstream to the lower limit of the section under observation. In Figure 5 are shown plots of the average density of coliform bacteria during March, under high water conditions, and in June-August, inclusive, which was marked by generally low river stages. Results for the stretch above Maysville were not available in March; hence no plot for this stretch under high water conditions can yet be shown. The June-August plot indicates clearly that the high coliform density immediately below Huntington during summer low water is due almost entirely to local pollution, as the results immediately above Huntington have been consistently low since June 1, when the observations were begun in this section of the river. The effect of pollution from the Cincinnati district on the coliform content of the river appears to be about ten-fold that of the wastes discharged from Huntington to Portsmouth. Below Cincinnati, it is noted that under March conditions the maximum coliform density was observed at Dam 38, about 30 miles downstream, whereas in June-August, it had moved some 20 or 25 miles upstream to a point above Dam 37. The tendency toward progressive reduction in bacterial content of the river due to natural purification is indicated by the downward trend of the plots below Ironton and Portsmouth and below the peaks just downstream from Cincinnati.

(Insert Figure 5)

In Figure 6 a similar comparison has been drawn between the trends of dissolved oxygen content (expressed as percentages of saturation) and of 5-day biochemical oxygen demand. Under high water conditions, both the D.O. and B.O.D. appear at a higher level than under low water conditions. The effect of pollution from Cincinnati caused very little depression in the D.O. curve during March, whereas in June-August, it produced a very sharp sag in this curve. In the section of river below Huntington and Ironton, and extending to a point just above Cin-

cinnati, a fairly typical oxygen sag curve is also shown. The cause of the apparent oxygen depression above Huntington remains to be investigated, though the observations indicate rapid recovery between Pt. Pleasant and Huntington.

(Insert Figure 6)

The tributary observations thus far made have shown a high degree of pollution throughout the entire lower section of the Miami River, in several zones of the Little Miami and its branches, and in sections of the Big Sandy, Guyandot and Licking Rivers. The lower Kentucky and Little Sandy Rivers have been shown to be in generally better sanitary condition than the other tributaries above noted, though in all of the tributary drainage areas degrees of pollution ranging from moderate to gross have been observed below most of the sewered towns and industrial centers. In a large majority of these instances thus far observed under summer low water, stream conditions have been found to be sufficiently insanitary to call for some degree of sewage and industrial wastes treatment. Some of the worst conditions have been found, as would be expected, below the larger towns located on the smaller tributary branches. In some of these cases both primary and secondary treatment of wastes would be required to restore favorable conditions.

In the Cincinnati office of the laboratory survey, large spot maps are maintained showing by means of colored pins the most recent conditions of pollution observed above and below each source of pollution, both on the Ohio proper and in the tributary streams. In this manner it is possible to determine at a glance where the "sore spots" thus far uncovered lie and where confirmatory observations are most needed. (See Figs. 7 and 8) In some instances, where the results indicate any marked depression in the dissolved oxygen curve below a source of pollution, further samples are collected at several points downstream in order to define the trend of oxygen "sag" and recovery.

(Insert Figs. 7 and 8)

Extension Plans

During the calendar year 1940, it is planned to move the survey upstream to the section of the Ohio and its tributary area extending some 260 miles above Point Pleasant to Pittsburgh and thence along the Allegheny and Monongahela Rivers. As no high water observations have yet been made in the upper half of the section now being studied, these observations will occupy the early part of the coming winter, when it also is hoped to examine the river from Point Pleasant toward Wheeling. If low water should continue until late in the coming fall months, the floating laboratory probably will be moved up into this section for some preliminary low-water observations.

With the advent of low water in the summer of 1940, it is expected to shift the base laboratories to the Pittsburgh-Wheeling-Parkersburg section and extend the observations both along the Ohio and its main tributaries. In this connection the mobile trailer laboratories will be utilized, as during the present season, to make observations in the more outlying areas of the watershed.

If it should be possible to complete the survey in the upper portion of the Ohio Basin in 1940, the survey will be shifted in 1941 to the lower section of the watershed including the main stem of the Ohio below the mouth of the Kentucky River and certain major tributary areas such as the large Wabash River basin. Owing to the large amount of work already performed in the Tennessee and Cumberland basins by the Tennessee Valley Authority and the Tennessee State Department of Health, little or no direct field or laboratory study will need to be given to these areas in connection with the present survey.

No knowledge exists at present as to whether the foregoing plans for extension of the survey can be carried to completion as now scheduled, though it is necessary, of course, to lay out such plans in considerable detail, on the

assumption that the survey will be eventually finished. When it has been completed, it will constitute probably the most extensive and detailed collection of field and laboratory data bearing on stream pollution and its effects which thus far has been carried out anywhere in the world. The data thus collected, when finally assembled and analysed, will provide the foundation for a comprehensive engineering plan of stream sanitation for the entire Ohio River drainage area. Such a plan, if carried to completion, not only will restore a basic resource of almost incalculable value to the millions of people inhabiting this great area, but also will afford an enduring demonstration, for the entire country, of the widespread social and economic benefits of clean waterways.

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